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Bass, Hans-Heinrich; Freyhold, Klaus von; Weisskoeppel, Cordula

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WATER MANAGEMENT AND WATER HARVESTING: HOW TO OVERCOME CONSTRAINTS IN COMMUNITY GARDENING IN SEMI-ARID MALI

Hans-Heinrich Bass[1+], professor Dr.; **Klaus von Freyhold**[2], Dr.;
Cordula Weisskoeppel[3], assistant professor (PD) Dr.
[1, 2] Bremen University of Applied Sciences, Germany
[3] University of Bremen, Germany

Abstract. Malnutrition, i.e. the undersupply of micro-nutrients, is a common phenomenon in the villages of West African Mali. Community gardening can help to overcome the gap between supply of and requirements for micro-nutrients. In addition to its effect on nutrition, community gardening supports the pro-poor orientation of economic growth, and has a potentially positive effect on human capital formation, communal coherence, and women's empowerment. Water supply, however, is a major bottleneck for gardening in the Sahel zone. Based on a field survey using a "rapid rural appraisal"-inspired research method, the paper develops the argument for a de-linking of irrigation from deep wells (water mining) and argues in favour of a combination of water harvesting techniques and substantial improvements of the gardens' micro-climate in a low external input yet technically appropriately sophisticated cultivation. The paper furthermore discusses traditional forms of social organisation and how to make them instrumental in supporting the new system.
Key words: malnutrition, horticulture, water harvesting, development assistance, gender relations
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Introduction

Over the past decades Mali's semi-arid area, part of the Sahel region, has experienced a sizable population increase, in relation to which regional rain-fed grain production is becoming increasingly insufficient. Commercial food imports from other regions in exchange for exports of labour and livestock cannot make up for the regional food deficit. To our understanding Mali's future will be decided in the rural areas. Supporting rural dwellers in producing more food of their own can be of relevance to reduce push factors of migration in a country which already faces a number of nationwide imbalances, including one of the world's highest urbanization rates and an extremely low rate of job creation in manufacturing.

We hypothesize that irrigation-based horticulture can contribute to bridging the gap between nutritional needs and food supply and to overcoming the undersupply of micro-nutrients, the "hidden hunger". However, access to water is the most important bottleneck of any food production in the Sahel zone: Not only has the rising human population but also the increase in transhumant livestock rearing put an immense strain on local water resources. We assume, however, that in contrast to water mining by means of deep wells which rapidly depletes limited water resources, rigorous water management and sophisticated water harvesting techniques can transitorily balance out supply of and demand for water (while in the long run population control and a substantial amount of non-agricultural economic activities are indispensable).

This paper provides a case study analysis of an NGO-assisted community garden organized by women in the village of D*** (region of Koulikoro). In a dead-end situation whereby the community garden had been abandoned by the village women apparently due to a lack of water, the NGO commissioned an interdisciplinary team of three researchers (agronomist, cultural anthropologist, and economist) to suggest a way out. Information was gathered by the research team inter alia during a field trip to the village of D*** in March / April 2012. By applying a "rapid rural appraisal"-inspired research method (FAO, n.d.), the team aimed at analysing the underlying causes for the interlocutory failure of the community garden and developing a blueprint for sustainable management of water resources and horticulture. As such, this study is essentially application-oriented research.

Research results and discussion

1. Overview

West African Mali is one of the world's poorest countries, ranking 175 out of 186 countries in the UNDP's 2011 Human Development Index as well as in the Multidimensional Poverty Index (UNDP, 2011). About half of its 14+ million population lives below the international poverty line of USD 1.25 per day. With a food consumption of 2,624 kcal/capita/day (data of 2009; FAOSTAT database) based on national production and on some food imports, the country on average still has only little more food available than what is considered to be the borderline to hunger (an average of 2,500 kcal per day), even if there has been some remarkable progress in terms of food security since the turn of the millennium. In 2010-12, however, 8% of the total population was still undernourished and one third of children under five were underweight (FAO, Food Security Indicators).

Agriculture is Mali's key industry. It provides employment for about 70% of the labour force and

[+] Corresponding author. Tel.: ++49-421-5905-0.
E-mail address: hans-heinrich.bass@hs-bremen.de.

accounts for 37% of its GDP (data of 2006; World Development Indicators, 2013). Seasonal unemployment in agriculture is common and lasts four to seven months per year, and is twice as common for women as for men (MEFP/ANPE, 2007, p. 30). Therefore, poverty affects three quarters of the rural population vis-à-vis one third of the urban population. Significant differences in the incidence of poverty also exist between the South and the North of Mali, reflecting inter alia different agricultural conditions and the respective distance from the relatively more affluent capital, Bamako, and its opportunities to market labour and farm products.

The long-term average annual rainfall in the area under investigation is about 450 mm. Apart from substantial year-to-year divergence, precipitation occasionally (as in 2011) seems to deviate from the usual seasonal pattern – a fact which is seriously detrimental for the crops. That said, however, in relation to the whole region, the village of D*** is favoured with regard to access to water thanks to its location at the confluence of three wadis, water-bearing during the rainy season and then draining into a depression ("mare") on the edge of the village and forming a lake usually still existent at the beginning of the dry season.

The village area consists of a core village with a population of about 600, living in 35 extended families of different size (up to 60 people), of which about 10% are temporary out-migrants. An extended family may consist of a man and up to four wives, adult sons and their wives, and occasionally other relatives. Associated with the core village is a satellite village where several families of descendants of former slaves live, while a number of nomadic families live in the outskirts of the core village. The annual population growth in the county, where the village is located is 3.2% (which is one of the highest in the world).

Livestock in the village area can be estimated to be 300+ bovines in addition to donkeys, horses, sheep, goats, and poultry. Livestock keeping is predominantly the responsibility of men. Annual livestock growth in Mali (compound annual growth rate, 2000 to 2010) is 4.4% for cattle and 5.7% for goats (computed from FAOSTAT data). As in other parts of the Sahel, excessive deforestation for firewood and fencing, soil compaction around the wells where animals are watered, the overuse of trees and shrubs for forage and a drop in the water table due to excessive water extraction all lead to decreasing biodiversity and eventually desertification. Actually, this is a situation rightly termed the "tragedy of (unmanaged) commons" (Hardin, 1968; Hardin, 1994), where the herder receives all of the proceeds from each additional animal while the pasture is slightly (for the individual almost imperceptibly) degraded by each additional animal. Humans, animals, and plants are thus in an ever-fiercer competition for water.

Regarding field cropping, a distinction has to be made between fields farmed by women and fields farmed by men. As a rule, crops on fields cultivated by women are more diversified; and sometimes a small part of the harvest from these fields – in contrast to the harvest from the men's fields – is traded at the markets of near-by villages. Millet (*Pennisetum glaucum*), occasionally intercropped with Sorghum, Peanuts, Okra, and Maize, is grown in a shifting cultivation mode on rainfed fields. In addition, some vegetables are grown in small compound gardens of which the elder women in the compound are in charge. Irrigation of these gardens is from nearby water holes by watering cans.

Over a number of years the village has been supported by a German-Malian NGO with various types of infrastructure assistance, including a school, an infirmary, and a grain mill. To improve food supply and to provide village women with an additional income source by marketing self-grown vegetables, the NGO has assisted the village of D*** in setting up a two-hectare communal garden, including the drilling of a deep well for irrigation in 2009. Apart from providing water for the communal garden, the well was also meant to provide the village population with uncontaminated drinking water. In addition to the well, the NGO provided assets such as simple tools, a wire mesh fence to protect the garden from goats, and also training for the gardeners. In the beginning, work in the community garden was "collective", but later on the women's association decided to work in four groups organized according to sub-ethnic divisions.

2. The rationale for community gardening

Community gardening in villages such as D*** does make sense for five reasons: the improvement of nutrition, the availability of cheap labour (in terms of opportunity costs) during the vegetation period of vegetables, the pro-poor effect, the improvement of the available human capital, and the strengthening of the social coherence of the village and the empowerment of the village women.

(1) Estimates suggest that nutrition in Sub-Saharan on average covers only 43% of the requirements for micro-nutrients (World Vegetable Center, n.d.). This "hidden hunger" is particularly pronounced in areas where agriculture is not sufficiently diversified and extra-regional trade links are poorly developed as well as among the poorer strata of society. A household-based health survey in Mali shows that in the country's capital 51% of the children between 6 and 23 months were fed fruits and vegetables rich in vitamin A (such as carrots, sweet potatoes, vegetables with green leafs, and pumpkins) – whereas this was the case for only 28% of children in the region of Koulikoro (where the village of D*** is located). Among the households of the richest quintile of Malian society, 45% provide their young children with food rich in vitamin A, while only 26% of the poorest quintile can do so (République du Mali …, 2007, p. 166).

An example shows the potential contribution of gardening to overcome the hidden hunger in D*** village: Calculations based on FAO and USAID data suggest that 18 tons of tomatoes can be produced on one hectare. As 100g of tomatoes provide 5% of the USDA's vitamin A intake recommendation for adults, tomatoes harvested on one half of the community garden would completely bridge the gap between actual intake and requirement of vitamin A for the whole village population for more than a month.

(2) Work in a community garden implies only minor opportunity costs for women: Time competition between work on the millet fields and gardening is very limited. In the area under investigation, the rainy season is from May to October, while the dry season is from November

to April. Preparation of fields for vegetable cultivation has to start in October. Thus, there is some overlapping with the millet harvesting until December. From January to March, however, no work is required on the millet fields and women are free to work in the garden, apart from cooking, as preparing meals is the responsibility of a compound's younger women who alternate with each other. Furthermore, only (young) men, not women, migrate from this area during the dry season in search of waged labour in other regions such as the country's capital. Thus, apart from gardening, village women would have hardly any alternative income sources.

(3) Labour-intensive gardening provides more food security especially for those families which do not possess large amounts of land or livestock – i.e. those most vulnerable with respect to a decline in food production. Gardening thus becomes instrumental in a pro-poor growth strategy. Our village survey (following a method proposed by Dixon and Holt, 2010) shows that 70% of the families are "poor", 20% are middle class, and 10% are "wealthy" by local standards, i.e. measured with the yardstick of family size (i.e. availability of labour force) and ownership of large livestock (a proxy for property of both capital and land).

(4) As will be described below in more detail, gardening based on a low level of external input but on more sophisticated cultivation and irrigation techniques provides opportunities to develop extra-agricultural skills (or human capital) for young men and qualifies them for relatively more rewarding jobs than those usually taken up by unskilled migrants.

(5) Finally, under certain conditions communal gardens – publicly functioning in terms of ownership, access, and management – can strengthen the villages' coherence and allow for a proper managing of the commons (see Hardin, 1994; Ostrom, 1990). Run by the village women, communal gardening also strengthens the position of women in terms of income generation and social and political empowerment and thus supports a more comprehensive and gender-balanced approach to development.

However, as water is scarce and irrigation is a conditio sine qua non for gardening in the Sahel zone, the prudent use of water is imperative. The sources of water in the village of D*** and their current management will be discussed in the next section.

3. Current management of water supply and demand

The water available in D*** is from three different sources of different qualities: water-holes, an old deep well, and a newly drilled deep well.

(1) At the end of the dry season a number of several-meter-deep wood-fortified water holes are dug on the ground of the depression (the "mare"). Water from these holes, however, is suitable only for watering animals. Supply of water from this source implies fixed costs due to the time spent digging the hole and the wood to fortify it. Once the water hole has been dug, apart from working time to fetch the water by human muscle power, no marginal costs accrue. In spite of the region generally reporting serious water shortage in March 2012, some of the holes on the ground of the depression were still water-bearing, but most holes were not in use.

(2) In addition to these water holes, a several-year old concrete-fortified, donkey-power operated deep well (about 1 km outside of the village) exists. It usually supplies water all-year round. Water from this source was also used as drinking water for the core village and the nomads before a new deep well was drilled by the NGO. After that, water from the old well was used only for watering the herds in the custody of the nomads and as drinking water for the nomads. Presently, no depreciation on fixed costs has to be considered as the well had been built years ago from external funds. The marginal costs imply only the working time spent fetching the water; no fees are imposed. Again, in 2012 the supply of water from this well was limited and allowed the herds to be watered only once or twice a day.

(3) Finally, there is the newly drilled solar pump-equipped deep well (depth 40 m) outside of the core village. From here, two water pipes run to the NGO-supported communal garden and to the brink of the core village. Water from the NGO-drilled well is best suited as drinking water for humans. The NGO indicated that due to the use of this water, the number of water-borne diseases (such as diarrhoea) especially amongst children had decreased significantly. As the NGO paid the bulk of the drilling costs of this well, the contribution of the village community to the fixed costs was only minimal. At the time of our field survey, consumption of water from this source was priced by the village's water committee according to a family-based flat rate, irrespective of the size of the family. Per person, an average of about 11 litres of water per day was taken from the well for drinking water as well as for personal hygiene and household-related purposes (like washing clothes). The nomads and the inhabitants of the satellite village are refused access to this water by the inhabitants of the core village. At the beginning of the communal gardening, water from this well was used for irrigation. During the drought of 2011, however, the village elders vetoed this practice due to a decreasing yield of the well.

4. New ways of water management

Contrary to a widely-held opinion in the media, however, the drought of 2011 was no "rare occurrence" in the village area. In fact, data for the average of all Sahelian measuring stations reveal that out of the 2000 to 2010 period, five years had a higher precipitation than in 2011, yet five years even had a lower precipitation (JISAO, 2012) – although the temporal distribution of rains was particularly adverse for the crops in 2011 (FAO, 2012). In any case, this warns against considering the de-linking of the D*** communal garden from the deep well to be an exception; it rather suggests that water shortages for the communal garden are an expectable phenomenon. Therefore, the opening up of an alternative water supply for the garden becomes imperative. This new model has three distinct features: water harvesting replacing water mining, improvement of the micro-climate in the garden, and introducing a new fee system for drinking water.

(1) Making use of the favourable situation of the communal garden adjacent to a wadi, water streaming down the wadi in the rainy season can be collected. This water harvesting is intended to be facilitated through

construction of, initially, one larger open cistern of 260 m^3 directly filled by the rain water passing at the lowest point of the garden area at wadi level. The cistern is to be wire meshed and covered with leafy branches to curtail as much evaporation as possible. Additional water can be drawn from shallow wells already in existence. From the cistern and the wells the water can be distributed to the fields either by watering cans or hand pumps. On-the-job learning to construct a cistern provides an opportunity for (young) men to develop skills also in high demand in other trades.

(2) The micro-climate in the garden has to be systematically improved in order to reduce evapotranspiration. Instrumental in protecting against strong winds and sun are hedges as well as scrubs on plot margins. For the hedge, a number of locally growing scrubs and trees are appropriate. Dividing the garden into smaller plots allows for additional planting of scrubs (such as *Cajanus Cajan*) on the plot margins. All this contributes to an increased humidity in the garden, which reduces the water required for cultivating the vegetable. To further diminish watering requirements, ridging need to be applied in all areas under cultivation. Ridges are better suited for rain water storage and for protection against rain water erosion in sloping areas than the "zaï" technique usually advocated for the Sahel area. In addition, fallow-periods need to be introduced, alternating between the plots and using legumes as intermediate crops.

The community gardeners will also be trained with respect to the selection of plants as well as how to successively improve the micro-climate and to make best use of the surface water. For the regular and secure supply of feasible and ecologically well-suited plants required for hedges and for agricultural production, a nursery field and a seedbed will be established directly at the cistern. A compost plant next to these two facilities will help to minimize the application of industrial fertilizer. In addition, the application of moist compost for fertilization will assist the improvement of the micro-climate in the plots.

(3) Finally, the present flat-rate system of fees for drinking water needs to be replaced by a system pricing the quantity of water consumed and thus providing incentives to use expensive uncontaminated water for drinking purposes only while making the effort to walk to the old deep well for water for household purposes. We assume that the total amount of water available in the area remains the same as a result of the interconnection of all sources. It has to be taken into consideration, however, that this implies a trade-off between the aim of freeing women from unnecessary work and using natural resources differentiated according to their qualities. On the other hand it is imperative to grant access to the uncontaminated water from the new well for both the nomads and the inhabitants of the satellite village. Given the intense social communication between the core village, the satellite village, and the nomads, water-borne diseases will not stop at the entrance of the core village.

5. New ways of social organisation

Enlarging the nutritional basis by introducing a community garden is a social and economic innovation in a truly Schumpeterian sense. To be successful, an innovation has to be linked to routinized behaviour but routines also need to be adapted to new conditions. With respect to the community garden, several forms of social organisation have to be considered in this respect, including the transfer of knowledge in horticulture, the organisation of co-operation, and the gendered division of labour.

(1) According to the compound-specific division of labour, the obligation to prepare meals for the whole compound alternates between the (up to four) wives of the head of the family. Older women may transfer this obligation to their daughter-in-law. The small compound gardens, however, are under the auspices of the older women, who are thus the local experts in horticulture. They also introduce the younger married women to the basic horticultural knowledge and skills. Gardening thus represents a female sphere of local knowledge production which is transferred from the older to the younger generation within kin-relations of alliance (not from mother to daughter, but from elder wife to younger wife). This is inter alia reflected in the fact that in the village of D*** the women's group is chaired by an elderly lady, clearly an expert in horticulture, and assisted by younger women able to read and write in French. Seniority is the dominant feature in gaining status and thus needs to be respected in all agricultural extension activities.

(2) The village women's association running the community garden in D*** includes about 80 participants (among them women from the satellite villages, but not from the nomadic population). For the purpose of dividing the right to access to water for the plants in the time of the drought and to assist each other in the vegetation period, the association divided themselves into four subgroups according to sub-ethnic or patronymic affiliation (i.e. to their kin of origin). This type of self-organization according to traditional sub-structures needs to be strengthened in the process of introducing a new system of organisation of cultivating the community garden, as it may enhance participatory involvement on an individual or subgroup level. Furthermore, it supports the division of the garden into smaller units, which is instrumental for the improvement of the micro-climate. Nevertheless, an external authority or coordinator of the group seems to be instrumental when re-organizing the community garden to facilitate communication with external players, such as funding agencies, especially in times of water shortages or other types of crises. This person (whether male or female) could also take responsibility for change management. The social organisation of cooperation proposed by the authors of the present study to accompany the technical changes in the water management and cultivation system is thus a mixture of the egalitarian collective approach taken in the early stages of the community garden project, the traditional type of sub-ethnically based organisation of the village, and a type of "rational" organisation according to the Western model.

(3) During the rainy season both men and women in the village are occupied with cultivating millet and other crops on their fields. While each gender bears the sole responsibility for the results of its work, men and women share their food within the extended families of

the compound to the benefit of all. By contrast, during the dry season only women seek to compensate their "free" time by gardening and contribute to a wider range of food for all, whereas men are more or less unemployed apart from taking care of the animals (in the core village) or temporary migration (from the satellite village). The availability of male labour at only low opportunity costs during the dry season suggests itself for assisting the women in the community garden by taking on tasks such as transport of stones to the building site of the cistern, fixing stones, planting hedges, transporting water, and cleaning the cisterns. It is obvious that by these strategies of involving men in the newly emerging activities of the community garden, there will also be changes in everyday relations between men and women and their established status. Nevertheless, it has to be emphasized that these changes will match the existing principles of a gendered division of labour. It is also instructive to know that in a different horticultural project for women in the same region, local *male* leaders were in charge of the organization and accepted by the female participants due to their legitimization by the NGO as principal teachers from the outset of the project in order to train the women adequately and continuously. This continuity of highly skilled supervision seems to have contributed to the long-term success of the whole project.

All in all, to our understanding this new type of social organisation – both based on traditional features and adjusted to new needs – lays the foundation towards a more sustainable way of governing commons (see Ostrom 1990, Nutzinger 2010).

Conclusions, proposals, recommendations

1. Community gardening in the Sahel area makes sense for five reasons: It improves the supply of micro-nutrients; it makes use of labour available at very low opportunity costs; it has a pro-poor effect; it improves human capital; and it strengthens the social coherence of the village and contributes to the empowerment of the village women.
2. As drought in the Sahel zone is the rule rather than the exception and competition for water increases, a community garden will only persist if an additional source of water can be tapped – the surface water available during the rainy season.
3. In addition to water harvesting techniques, improvements of the micro-climate in the gardens are imperative. Instrumental for improving the micro-climate are hedges, scrubs planted on the edges of small plots, and planting in ridges (an equivalent to the much-propagated zaï-technique modified for sloping fields).
4. The social organisation of the garden needs to build on traditional features and develop them into a system more favourable to governing a common resource. This pertains to the transfer of knowledge in horticulture, the organisation of co-operation, and the gendered division of labour.

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